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to the main portion by fourth difference interpolation formulas. The upper tail end of the curve was graduated by Wittstein's formula and welded to the main portion by the application of Spencer's 21-term formula. Glover felt it important to alter the raw figures as little as possible and apologizes in various places for little roughnesses in the tables, especially around junction or welding points.

Much might be said about the orthodox actuarial philosophy regarding the smoothing or graduation of raw data. The present reviewer finds himself in disagreement with some of it, looking at the whole matter from the broad standpoint of scientific methodology. But this is clearly not the place to enter upon a discussion of this mathematically recondite and emotionally delicate subject. Suffice it to say that the reviewer is acquainted with no more honest, thorough, and skillful application of the standard actuarial methods than that of Glover in the construction of these tables.

Altogether this is a substantial and notable contribution to American vital statistics. We may well be proud of it. It stands at least on a level with the very best that any country, not excepting the Registrar-General's Office of England and Wales, under Farr and Ogle and Stevenson, has produced in the same line. Every health officer and vital statistician should have a copy of it on his desk. Two features of the book are especially noteworthy. The first is that the best recent life tables for Australia, Denmark, England, France, Germany, Holland, India, Italy, Japan, Norway, Sweden, and Switzerland are given in full for comparative purposes. The second is that there are given, for the United States, tables of life annuities, premiums and commutations. This last is an interesting departure for an official government publication. Hitherto in litigation involving questions of life expectancy in the settlement of estates, etc., the courts have had to depend for their actuarial basis in the main upon the material of insurance companies. Now official tables based upon the experience of the original registration states in 1910 may be used, and all elements of uncertainty as to bias will be removed. Furthermore, by the use of the premi-

um tables one can make intelligent examination of the alluring proposals made to him for the purchase of insurance, whether by theoretically grasping commercial institutions or by theoretically eleemosynary foundations.

Finally, it may be pointed out that this volume makes a first rate text-book for the systematic study of the basic elements of actuarial science. The reviewer is using it in this way at the present time, in a course in life table construction, with great satisfaction. It may be purchased from the Superintendent of Documents at a cost of \$1.25 per copy, cloth bound, a price which is only a small fraction of what any commercial publisher would have to charge for a book so expensive to manufacture.

RAYMOND PEARL

SPECIAL ARTICLES

X-RAY CRYSTALLOMETRY: X-RAY WAVE LENGTHS, SPACE-LATTICE DIMENSIONS AND ATOMIC MASSES

THE fundamental equation in X-ray spectrometry and crystallography is

$$\lambda = 2d \sin \theta$$

wherein d is the perpendicular distance between adjacent planes in the crystal which reflect in the first order at a glancing angle of incidence θ , X-rays of wave-length λ . Since only θ in this equation is capable of direct measurement the absolute magnitudes of λ and d can only be determined if some other relation between them can be found, or if either can be determined independently.

The method first used was to obtain a value of d from the density of the crystal, the number of molecules in its unit of structure, and the mass of a single molecule. The first of the last-named quantities can be measured directly, the second is an integer the choice of which can be guided with sufficient accuracy from the X-ray data, and values for the third have been obtained by a variety of methods, perhaps best by the determination of electrochemical equivalents and electronic charge. No other relation between λ and d than that given above is at present known to exist, *i. e.*, no other quantity than θ is known to depend upon these two variables only, so that the first suggested method of

getting their absolute magnitudes is not feasible.

An independent method of getting d is to employ the quantum relation between wavelength of X-rays and volts required to give electrons equivalent energy. In using this method we must take care to leave out of account those values of h which themselves depend upon X-ray wave-lengths.

Using the first method we select the following data:

Number of molecules per	
mol, $N = 6.0594 \times 10^{23}$	(1, 5)
Density of calcite.....	2.7116 gm/cm ³ (2, 5)
Interaxial angle for calcite.....	101° 55' (3, 5)
Molecular weight CaCO ₃	100.07 (4)

The volume of the unit rhombohedron is 1.09626 \AA^3 and it contains one half of a molecule⁶ so that the grating constant $d = 3.02855 \times 10^{-8}$ cm. The ratio of the grating constant of calcite, d_{CaCO_3} to that of rocksalt, d_{NaCl} , has been determined by Uhler and Cooksey⁷ and by Siegbahn⁸, their respective values being $\frac{3.0307}{2.814} = 1.07701$, and $\frac{3.02904}{2.81400} = 1.076417$ ($\log^{-1} 0.0319806$), the latter of which is the more accurately determined and will be taken as the true ratio. This requires that d_{NaCl} be changed to 2.81355×10^{-8} cm. The values given by Duane⁹ for these two constants are 3.028×10^{-8} and 2.814×10^{-8} , the ratio of which, 1.07605, is probably a little low. To correct Duane's wave-lengths to the new

basis we must multiply those based on 3.028×10^{-8} for d_{CaCO_3} by $\frac{3.02855}{3.02800} = 1.00018$, and those based on 2.814×10^{-8} for d_{NaCl} by $\frac{2.81355}{2.81400} = 0.99984$.

It should be noted further that Siegbahn¹⁰ has more recently obtained a value for $\frac{\lambda}{d} = \sin \theta$ for the $K\alpha_1$ line of copper which does not agree with that which he obtained at the time the above-mentioned ratio was obtained. His new value for λ is 1537.302×10^{-11} for $d_{\text{CaCO}_3} = 3.02904 \times 10^{-8}$ as compared with the previous value 1537.36×10^{-11} for $d_{\text{CaCO}_3} = 3.028 \times 10^{-8}$. Referred to the same basis (the new value of $d_{\text{CaCO}_3} = 3.02855 \times 10^{-8}$) this means a change from 1537.64×10^{-11} to 1537.056×10^{-11} , a decrease of 0.038 per cent. Since this correction amounts to more than the difference involved in changing 3.028×10^{-8} to 3.02855×10^{-8} and 2.814×10^{-8} to 2.81355×10^{-8} , and since Compton's value for the density of rock-salt has been criticized as probably too low¹¹ it seems premature on the basis of the above evidence to decide in favor of either of the two constants used by Duane.¹²

A recent note by Davey¹³ bases a similar analysis upon a value of $N = 6.0642 \times 10^{23}$ and upon 2.173 gm/cm³ as the density of rock-salt, thus getting a spacing for the (100) planes in this crystal of only 2.810×10^{-8} cm. Adoption of this value would require extensive correction of all reported wave-lengths without any considerable advantage, and observers agree that rock-salt is a less suitable standard than calcite, on account of the greater probability of inclusions leading to abnormally high densities. The density corresponding to the value here chosen for d_{NaCl} , 2.8135×10^{-8} ,

¹⁰ M. Siegbahn, *Comptes Rendus*, 173, 1350-1352 (December 19, 1921).

¹¹ R. Ledoux-Lebard, A. Dauvillier, *Comptes Rendus*, 169, 965-967 (November 24, 1919); H. S. Uhler, *loc. cit.*⁵.

¹² *Loc. cit.*⁹; cf. M. Siegbahn, *Jahrb. d. Rad. u. Elektr.*, 18, 240-292 (1921).

¹³ W. P. Davey, *SCIENCE*, 54, 497-498 (November 18, 1921).

¹ R. T. Birge, *Phys. Rev.*, (2), 14, 365 (1919).

² A. H. Compton, *Phys. Rev.* (2), 7, 646-685 (1916).

³ P. Groth, *Chemische Kristallographie*, 2, 204 (1908).

⁴ "International Atomic Weights," (1921).

⁵ H. S. Uhler, *Phys. Rev.* (2), 12, 39-46 (1918).

⁶ This is not a true unit of structure, which, however, is of no importance for these calculations; cf. R. W. G. Wyckoff, *Amer. Jour. Sci.*, 50, 317-360 (November, 1920).

⁷ H. S. Uhler, C. D. Cooksey, *Phys. Rev.*, (2), 10, 645-652 (1917).

⁸ M. Siegbahn, *Phil. Mag.*, (6), 37, 601-612, (1919).

⁹ W. Duane, *Nat. Res. Council Bull.*, 1, 383-408 (November, 1920).

and to $N = 6.0594 \times 10^{23}$, is 2.166 gm/cm^3 or only a little lower than the lowest value quoted by Davey.¹⁴

The value $N = 6.0594 \times 10^{23}$ is equivalent to a factor 1.65033×10^{-24} ($\log^{-1} 24.2175704$) for converting atomic or molecular weights to grams.

The second method, depending upon the value of h , requires in addition a determination of the potential applied to an X-ray tube. The work of Blake and Duane¹⁵ may be considered as a determination of d in terms of h . The values of h collected by Birge¹⁶ vary somewhat among themselves but 6.560×10^{-27} seems a reasonable mean value of the results not depending upon X-ray wave-lengths, and this gives $d_{\text{CaCO}_3} = 3.0303 \times 10^{-8}$ or 0.058 per cent. higher than the value given above. This is within the range permitted by the probable error in the value of h just taken.

The following constants are therefore recommended to be used until other values are agreed upon, to the accuracy indicated by the logarithms.

Grating space of calcite:

$$3.028 \times 10^{-8} \text{ cm. } (\log^{-1} 8.48116)$$

Number of molecules per mol:

$$6.0594 \times 10^{23} (\log^{-1} 23.78243)$$

Molybdenum K-radiation wave-lengths:

$$\alpha_1 0.70783 \times 10^{-8} \text{ cm. } (\log^{-1} 9.84993)$$

$$\alpha_2 0.71212 \times 10^{-8} \text{ cm. } (\log^{-1} 9.85255)$$

L. W. MCKEEHAN

RESEARCH LABORATORIES OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY, AND THE WESTERN ELECTRIC COMPANY, INCORPORATED,
SEPTEMBER 20, 1922

PERIPHERAL MIGRATION OF A CENTRIOLE DERIVATIVE IN THE SPERMATO- GENESIS OF *ECANTHUS*

IN 1920 Mr. Chas. S. Driver began at Columbia University a study of the male germ cells of a common tree-cricket, *Ecantus nigricornis* Walker, an Orthopteron insect of the family

Gryllidae. His preliminary study convinced him that, during the changes undergone by the spermatid as it begins to lengthen into the mature sperm, the entire distal centriole migrates posteriorly along the axial thread, eventually forming a terminal "plug" for the caudal sheath at its distal extremity. While a peripheral migration of part of the central apparatus in the spermatids of invertebrates was not hitherto entirely unknown, previous accounts are few in number and somewhat conflicting in substance. A reexamination of this phenomenon was, therefore, of considerable interest. The untimely death of Mr. Driver left his work incomplete and his material was delivered to me for further study. Driver deserves much credit for the excellence of the preparations, which are remarkably well fixed and stained. The method of Benda was used for fixation, and the sections were stained according to the alizarin-crystal violet technique. My observations were made at a magnification of 1,100 to 1,650 diameters, somewhat higher than that used by Driver in his survey of the material.

After a careful study I have reached a different conclusion in regard to the migrating "centriole" from those of Driver and earlier observers. Although there is in the spermatids of *Ecantus* a peripheral migration of a body which appears much like a centriole and stains in a similar manner, I am able to demonstrate that the migrating body is not an entire centriole, but only a portion or derivative of the distal centriole.

In early spermatids of *Ecantus* the central apparatus appears as a bar which lies perpendicularly to the nuclear membrane. The axial thread has already appeared at this early stage. The bar constricts in the center, dividing into a proximal and a distal centriole. Almost immediately a small portion of the latter, encircling the axial thread, is budded off and begins a migration along the thread. As it moves distally it increases rapidly in size, and eventually becomes as large as both proximal and distal centrioles combined. It reaches a permanent position at the distal extremity of the caudal (mitochondrial) sheath. The remainder of the distal centriole continues to lie

¹⁴ *Loc. cit.*,¹³ assuming the value attributed to Retgers is 2.167 and not 1.167 as printed.

¹⁵ F. C. Blake, W. Duane, *Phys. Rev.*, (2), 10, 624-637 (December, 1917).

¹⁶ *Loc. cit.*,¹